Modeling and Simulation Requirements for Unit Level Training at the Operational Level of War

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ABSTRACT: *To economically produce expert Command and Control crew members, personnel must participate more frequently in meaningful training experiences. Current Air and Space Operations Center (AOC) training requires active duty personnel to attend only one major and three minor exercises every year. Air National Guard and Air Force Reserve personnel are required to attend one major and three minor exercises every three years to meet continuous training requirements. Currently there are significant gaps in our ability to provide training for many AOC positions due to the change in focus from tactical operations to the operational level of war. At the operational level of war, the stimulus for training is the information provided, not the movement of entities in a synthetic battlespace. Large scale exercise planners spend months developing background information to support an exercise spanning operational and tactical requirements. We do not have the resources or capabilities at the unit level to develop this background information. This gap is especially apparent in the Strategy Division of the AOC, which operates at the operational level of war and relies on a magnitude of information inputs to determine Courses of Action and guidance to be implemented days or even weeks in the future.*

This paper examines the problem and identifies requirements for modeling and simulation tools to fill the unit level training gap at the operational level of war.

Keywords: Training, Modeling and Simulation, Command and Control

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14. ABSTRACT

This paper examines the problem and identifies requirements for modeling and simulation tools to fill the unit level training gap at the operational level of war. To economically produce expert Command and Control crew members, personnel must participate more frequently in meaningful training experiences. Current Air and Space Operations Center (AOC) training requires active duty personnel to attend only one major and three minor exercises every year. Air National Guard and Air Force Reserve personnel are required to attend one major and three minor exercises every three years to meet continuous training requirements. Currently there are significant gaps in our ability to provide training for many AOC positions due to the change in focus from tactical operations to the operational level of war. At the operational level of war, the stimulus for training is the information provided, not the movement of entities in a synthetic battlespace. Large-scale exercise planners spend months developing background information to support an exercise spanning operational and tactical requirements. We do not have the resources or capabilities at the unit level to develop this background information. This gap is especially apparent in the Strategy Division of the AOC, which operates at the operational level of war and relies on a magnitude of information inputs to determine Courses of Action and guidance to be implemented days or even weeks in the future.

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1. Introduction

A military's biggest asset is not its weapons supply, but the people who operate the weapons systems. Highly successful military organizations are set apart from the rest by their approach to training their people. In recent years, the application of distributed simulation to training has resulted in ever increasing use of distributed mission training. The United States Air Force adopted the distributed mission training construct in 1997 and is expanding the use of this construct through the Distributed Mission Operations program. While initially focused on the training of pilots, the ultimate vision of this program is to apply the technology across all operational domains. Perhaps the most challenging domain for applying these technologies is in the command and control domain, especially with the organizations tasked with conducting operational planning. Within the United States Air Force, the organization tasked with operational planning and execution is the Air and Space Operations Center (AOC).

The AOC is the senior element of the Theater Air Control System (TACS). It provides operational level command and control of air and space forces as the focal point for planning, directing, and assessing air and space operations. Although the US Air Force provides the core manpower capability for the AOC, other service component commands and coalition commands contributing air and space forces provide personnel in accordance with the magnitude of their force contribution. Each AOC assigned to a contingency is organized specifically to meet the requirements of the contingency. [2]

An AOC is typically organized into five divisions and multiple specialty teams. The divisions include Strategy; Combat Plans; Combat Operations; Intelligence, Surveillance, and Reconnaissance; and Air Mobility. Specialty Teams include Communications, Information Warfare, Space Operations, Special Operations, and Judge Advocate. Core manning is the responsibility of a Numbered Air Force with an Air Operations Group (AOG) assigned. When tasked to support a particular contingency, the Numbered Air Force commander will direct the formation of an AOC using the organic AOG augmented by personnel from other organizations. None of these personnel are trained in AOC operations in their basic career field training. [2]

AOC operators need to be mission ready in their specialty areas and are expected to use their knowledge and experience to provide subject matter expertise to the planning and operations functions. Additionally, since the AOC is the interface between the operational art of war and tactical execution, operators are expected to be versed in professional knowledge gained from professional military education and reading. Joint and aerospace doctrines are also required knowledge areas for AOC operators. Finally, the AN/USQ-163-1 Falconer system, the formal designation of the AOC weapon system, consists of over 70 systems and applications which are used by the various operators. [2]

One of the greatest challenges for consistent, effective and efficient AOC operations has been the frequent influx and outflow of personnel. Formal training, made possible by the weapon system designation, is an essential element in reducing the transitional slow-downs inevitable when personnel enter and exit the AOC arena. The challenge is to develop unit level training that can be targeted at an individual's or teams's specific training needs, and provide that training in a manner which will raise the proficiency level of the individual rapidly.

The traditional means of unit level training for the Air Force has been a combination of 'rock drills' and exercises. Rock drills consist of team discussions of the various processes where the team members pass the 'rock' to the next person or cell responsible for a portion of the process. Exercises are the measure of mission readiness, and current mission qualification and continuation training require active duty personnel to attend only one major and three minor exercises every year. Air National Guard and Air Force Reserve personnel are required to attend one major and three minor exercises every three years to met continuation training requirements. However, attendance at these exercises does not measure or assess individual performance, or even quantitatively grade overall team performance; they simply provide the capability to gain experience through practice.

From a training research perspective, there are three steps that need to be taken to transform 'practice' exercises into training exercises: mission needs analysis, training gap analysis, and training development and implementation. Mission needs analysis ensures that requirements are accurately focused on the needs of the warfighter based on quantitative analysis. These needs are applied in training gap analysis to identify warfighter needs that are not represented in current training. The resulting changes are applied to existing training, or are used to develop new and innovative training methods.

The Warfighter Readiness Research Division of the Air Force Research Laboratory, in cooperation with Air Combat Command has conducted mission analysis of the AOC using the Mission Essential Competencies[SM] (MECs[SM]) development process. MECs are "higher-order individual, team, and inter-team competencies that a fully prepared pilot, crew or flight requires for successful mission completion under adverse conditions and in a non-permissive environment"[1]. MECs are augmented with supporting competencies, knowledge and skills, and experiences. Once the MECs are developed, a battery of surveys are given to the operational community and the results analyzed to identify training gaps for each team in the AOC. The resulting gaps are the baseline for creating training that goes beyond practice exercises to worthwhile training opportunities.

This paper will use, as an example, the training requirements for the Strategy Division of the AOC. The Strategy Division is responsible for development, refinement, dissemination, and assessment of joint air and space strategy [11]. In this role, the division focuses on the future, days and weeks ahead and develops the plans and guidance to direct the future operations. Additionally, members of the division monitor current operations to assess their effectiveness and to identify potential changes in the future plans and guidance. The Mission Essential Competencies for the Strategy Division are [3]:

- Conduct Mission Analysis: *Evaluate the environment of blue and red (Intelligence Preparation of the Battlespace (IPB) and Predictive Battlespace Awareness (PBA)) to provide an understanding of how to utilize influence zones; evaluate the current mission; write and recommend Joint Force Air Component Commander statement.*
- Select Course of Action (COA): *Develop potential courses of action and criteria to rate their feasibility; compare COA in relation to mission objectives; select COA based on established criteria; champion and recommend the proposed solution to the decision-makers and support execution planning for the chosen COA.*
- Produce and Assemble Products: *Assemble products outlining the developed strategy (e.g., Joint Air Operations Plan, Annexes, Air Operations Directive, inputs to Special Instructions) by compiling input from Strategy teams and according to appropriate formats; ensure products meet JFC guidance and intent; distribute products using most efficient means available.*
- Assess AOC Products and Processes: *Review AOC products/processes (Air Strategy, Air Plan, internal processes) and communicate recommended changes using the most efficient means available.*
- Maintain Awareness of Assets: *Understand capabilities, limitations, and availability of air assets; both current and future; both traditional and non-traditional.* [Mission Essential Competencies for AOC Strategy Division]

The focus of the Strategy Division of the AOC is at the operational level of war. At this level, the operational planners attempt to anticipate the future from the present and develop a course of action that will allow them to achieve the objectives of the commanders above them. The MECs require the operators to focus on what might happen days to weeks in advance and identify potential approaches to meeting these challenges. Effectively, they are playing chess with thousands of pieces and squares and like any chess player, are looking ahead a number of moves to plan their strategy.

2. Implication to Modeling and Simulation

At the operational level of war, the stimulus for training is the information provided, not the movement of entities in a synthetic battlespace. Because of the difference in stimulus, current modeling and simulation technologies do not lend themselves to providing immersive training environments for personnel in the Strategy Division. Most training simulations are designed to accurately depict the maneuver and engagement of individual platforms or organized groups of platforms. When used in training exercises for units at the operational level of war, these simulations are augmented through the addition of information provided in some form to the operational planners.

Large-scale exercises that define current AOC continuation training require exercise planners to spend significant resources developing the background information to support the exercise. The scope of this information varies based on the exercise. At the low end, the databases used by the command and control applications are populated, and specific information in the form of guidance and intelligence are provided manually to the operators at the appropriate times in the exercises. Better-funded exercises may develop the means to provide

information through a variety of media to increase the fidelity of the exercise and more deeply immerse the training audience in the operations. Additionally, such exercises generally use a number of personnel to support the exercise, either formally designated as a 'white force' or augmentees to fill gaps in the organization. In the case of augmentees, often their primary function is to play a role or be a training aide rather than actually being a member of the training audience.

The required investment in resources and personnel to support such exercises is beyond the capability of the units tasked with mission qualification and continuation training. These units generally have a single person assigned to organize and monitor the training for both the Strategy and Combat Plans Divisions. While this person may be invited to participate in exercise planning and identify training objectives for the training audience, such objectives will generally be very high level and will not be able to specifically address either individual or team training needs.

We have developed a concept called information simulation to meet the needs for unit level training. Since the primary stimulus for the training audience is information, the concept envisions the development of tools to cost-effectively develop the background information in a variety of media and then deliver the information to the training audience and measure their performance against the training requirements identified by the Mission Essential Competencies.

The Strategy Division integrates a variety of guidance and information from multiple sources to develop the courses of action and the implementing orders. First, and foremost, the division receives guidance that has flowed from the National Command Authorities to the Combatant Commander, to the Joint Force Commander, and finally to the Component Commanders. At each level, objectives are identified or derived that that provide the specific direction to the Strategy Division. At each level, the associated staffs have clarified and expanded the guidance to hopefully provide the division a better understanding of the overall environment.

Second, and almost as important, are the strategies and plans that are being developed by both the Joint Force planning staff and the planning staffs of the other component commands. The Strategy Division must consider both land and maritime operations and how the air operations are designed to both protect and complement these operations.

Third, the various intelligence organizations have collected and analyzed massive amounts of information about the area of interest and its occupants that must be considered when developing a course of action. As the contingency develops, additional information comes in that requires the division to revise and adjust the strategies.

Fourth, since the militaries do not operate in a vacuum, inputs and requirements from non-military sources, other government agencies and non-governmental agencies, must also be considered through the planning cycle.

Fifth, the requirement to maintain awareness of assets requires the division to maintain liaison with the logistics organizations of the air forces assigned to the operation to understand the capabilities and appropriately task the forces.

Sixth, since such contingency operations are the focus of the world news media, the products of the news media are a stimulus that must be considered by the division as they develop and refine the courses of action and orders.

Finally, a team within the strategy division is tasked to monitor current operations and assess their effectiveness against the stated objectives. This team provides a key source of information to the planners that may require them to radically change their thinking and modify their approaches.

The appropriate simulation of information requires that the information be delivered in the appropriate media. Within the AOC, information is received through almost any media that can be imagined. Word documents, spreadsheets, and briefing slides are three of the most common media that must be supported. Meetings and briefings, both actually attended or attended through telephone, video, or computer teleconferencing are also important sources of information. Information is also received through formal messaging, e-mail, and electronic chat. Remote suppliers of information may update databases and web sites may be updated and revised as new information arrives. Finally, the ability to monitor the world media is usually available to the operators.

Information simulation also requires that information be provided at the appropriate time. The timing of a delivery depends on both the unfolding of a scenario and the individual and team training requirements for the particular exercise. Delivery of information may

also be event-based and only occur if a pre-defined event occurs in the exercise. Experience with simulation-based training suggests that the effectiveness of the training is directly related to the realism of the training environment, and appropriate timing is a key factor to realism.

Information simulation requires the development of a new family of modeling and simulation tools designed specifically for the training of mission essential competencies at the operational level of war. These tools will be designed and developed to support unit level training requirements. The remainder of the paper will focus on our initial concepts for these tools.

3. Requirements for Modeling and Simulation Tools

Using modeling and simulation technology to create decision environments for exercising and training Command and Control (C2) personnel is not a new concept or requirement. Constructive simulations have been successfully used to provide training and rehearsal for C2 personnel for decades.

Mission Essential Competencies provide a framework for requirements for training not only for large organizations such as the AOC and teams of teams but also small teams and individuals. Both large organizations and small teams benefit from recurring training events and experiences. For command and control exercises, the same simulation components are needed for both large organizations and small teams. The information simulation requirements for small teams are dependent on the same information simulation capabilities needed for large scale exercises. However, current approaches are not economical for training small teams. We believe that Science and Technology (S&T) investments in four key areas need to be made in order for unit level training to become effective, meaningful, and economical.

First, we need a revolution in *scenario authoring tools*. As we continue to gain an understanding of what the best approach is for training individual human beings and specific teams of human beings, we need systems that can rapidly adapt to individual and team needs automatically. The time required to author a scenario needs to be reduced. Scenarios need to be based on specific individual and team needs rather than on a high level concept of what the training audience needs. In the future, highly automated scenario authoring tools should create an environment that can focus on weak areas and provide opportunities to strengthen individual and team skills [7]. For example, if one team excels at the Produce and Assemble Products MEC but is weak in the Select Course of Action MEC, scenario authoring tools should identify vignettes and events to focus on the unique weak areas and produce scenarios tailored to strengthen the Select Course of Action MEC.

The large volume of multi-media information available to and utilized by AOC planners necessitates that automated scenario authoring tools be capable of producing an environment that adequately allows teams to build proficiency in the Conduct Mission Analysis MEC including all of the information that is required to be able to complete the IPB and PBA processes. Although the Air Force IPB process is complex as described in the 182 page Air Force Pamphlet 14-118 [4], it is conceivable that intelligent agents could be developed and integrated into scenario authoring tools to build the information environment needed for unit level training.

Time thresholds for a scenario developed in the future need be reduced to weeks. The objective would be to go from scenario concept to implementation in days or even hours. This may sound trivial at first glance, but after considering all of the detailed information that needs to be present and correlated to make training meaningful, the complexity of the challenge becomes clear. For example, consider that developing actionable intelligence to support the Conduct Mission Analysis MEC can often takes weeks or even months. Certainly the militaries of today are capable of finding and prosecuting targets much faster than in the past largely in part due to the ability to move and process information better than ever. Still, much information is pre-processed and making decisions at the operational level of war adds additional factors that must be present for meaningful training events. The complexities of new mission areas including space and cyberspace also need to be factored in for unit level operational training events [8].

Second, we need *synthetic teammates* comprised from human behavior models or cognitive models capable of seamlessly integrating with real-world systems and operators as synthetic white force players and teammates. The benefit here is that a unit or individual can gain from participating in a large scale exercise without the cost and overhead of numerous human beings. Additionally, this approach would save precious man-hours and provide some relief to specialties such as intelligence from being

consistently tasked as training aides for command and control personnel. In our C4ISR training research laboratory we've demonstrated the ability of human behavior models to represent portions of the AOC's Intelligence, Surveillance, and Reconnaissance Division (ISRD) to provide exercise inputs into a until level training event. The synthetic white force team monitored work to identify targets for the human team and even interacted with human players using rudimentary chat functions. We are now developing ways for synthetic players to interact with real-world systems such that communications with human players and real-world players will be seamless. Although there is still much work to do before these synthetic warriors will be at the level they have the potential to become, it is encouraging to see the opportunities and flexibility this capability could provide as technologies and techniques mature. It is critical to continue work in this area to realize meaningful and economical unit level operational training in the future.

Third, we need seamless *automated performance assessment tools*. A lot of groundbreaking work has been done in automating performance assessment during the last decade. Technologies have advanced in both the defense industry and in the open marketplace. For example, some high school curriculums depend on sites like www.turnitin.com to grade essays [9]. As competency-based behavioral correlates are identified for assessing unit level training, systems could automatically assess individual and team performance. Solid work has been done in this area for the tactical domain [6, 10]. However, the complexities of the information environment and the vast information simulation environment needed for operational level training complicate developing effective automated performance assessment tools.

The ability of future automated performance tools to seamlessly feed information back to scenario authoring tools is also key to reducing scenario development time and producing economical solutions. Ideally, scenarios should be created to address specific requirements or weak areas for teams and individuals based on the past performance of the team or individual. Tools should seamlessly read or monitor performance indicators and generate or adapt the scenarios based on those performance parameters.

Fourth, the supreme *learning management system* must be realized. Supreme is a future management system that drives scenario authoring based on performance assessment and readiness requirements. The system then configures the environment including the selection of appropriate human behavior models for the competency-based event and initializes the event. Learning management tools that provide the ability to store or warehouse scenarios that can be quickly adapted is also highly desirable. Emerging standards for scenario development need to include provisions for customization for an individual or small team.

The learning management systems and scenario authoring tools must be based on an efficient strategy for initializing meaningful training events. In some cases, organizations have designed geographical locations and associated scenarios in order to ensure certain competencies are addressed and that information can be correlated. While this has the benefit of reducing political sensitivities, constraining the problem at hand, and providing a high degree of control, it also has some disadvantages. Effort spent understanding the road to war and other background information about a fictitious geographic location could yield a dual payoff if real-world locations, background information, and evolving events were used as the starting point for simulated events. Personnel would reap the benefit of becoming familiar with real world information that would improve long term situational awareness and contribute to the deep understanding and familiarity that breeds mission success for operating in real-world areas if needed. Additionally, the large amount of resources already being applied by various organizations to present the latest intelligence and information could be leveraged.

Based on the operator feedback we have received this year, real-world situations could serve as a baseline for initializing simulations. This approach is not necessarily a new idea but one that has not been fully leveraged today. Fiscal constraints challenge the wisdom and vitality of continuing to invest scarce dollars into simulation environments that do not contain a baseline founded on real data at the operational level. Tools need to be developed that can seamlessly integrate simulation environments with real-world systems [5], not just to use the simulation environment to drive the real-world systems, but also to use real-world databases to initialize simulation environments.

Key to a bright future for unit level training at the operational level of war is *scenario authoring, synthetic teammates, automated performance assessment tools*, and the next generation in *learning management systems.* This system of systems must be a seamless suite of advanced capabilities that can drive scenario authoring, auto-configure the

environment, assess performance, and by extension provide time appropriate job-aiding and cueing. One can imagine how such a system capable of initializing from real-world data, adjusting the simulation environment and scenario to exercise key competencies for specific individuals and teams, dialing up needed human behavior models capable of adapting to human behavior in real-time, and then orchestrating and monitoring the outcome would enable us to train individuals at a new level of proficiency not seen to date.

4. Summary

In order to economically produce expert Command and Control (C2) warfighters, it becomes necessary to train the individual or team in a realistic immersive environment. In the case of Strategy Division personnel, training in an operationally representative environment becomes difficult due to the need to simulate information as opposed to constructive entities.

To effectively address this problem, three steps need to be taken to revolutionize the way we train our C2 warfighters, more specifically Strategy Division personnel. We have conducted the mission needs analysis, and training gap analysis identified the Mission Essential Competencies and needs that are not being addressed by current training. Now, the tools that will allow cost effective and timely training that addresses these areas must be developed and implemented.

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